Diseases of the Urinary System

CHAPTER 10

Learning Objectives

After studying this chapter, you should be able to

- Describe the primary functions of the major organs of the urinary system—the kidneys and the urinary bladder
- Identify the etiology, signs and symptoms, diagnostic tests, and treatment for selected diseases of the kidney
- Describe the etiology, signs and symptoms, diagnostic tests, and treatment of urinary tract infections (UTIs)
- Differentiate between ascending and descending modes of urinary tract infections
- Explain how urinary tract infections affect or dysfunctions affect other organ systems
- Distinguish among the various modes of kidney dialysis.
- Identify the etiology, signs and symptoms, and treatments of various types of kidney stones (renal calculi)
- Describe causes and treatments of inflammation within the urinary bladder and urethra
- Contrast neurogenic bladder with stress and other forms of urinary incontinence
- Recognize the etiology, signs and symptoms, and treatment for bladder cancer
- Describe age-related changes of the urinary system

Fact or Fiction?

Renal calculi, or kidney stones, form only in the kidneys. They also form in the population equally throughout all regions of the United States.

*Cause is unknown.*

Renal calculi, also known as kidney stones, are formed by the crystallization of substances within the kidneys. The exact causes can vary, but common factors include high urine pH, high levels of calcium, and low fluid intake. While they are most common in the kidneys, they can also form in other parts of the urinary system such as the bladder and urethra.

Fiction: Renal calculi may form anywhere within the urinary system.
In 1913, a pharmacologist at Johns Hopkins University named John Abel published an article about hemodialysis using animals. In the 1930s Dr. Willem Kolff, who at the time was struggling to develop an artificial kidney in the Netherlands, read the article and was curious about applying Abel’s concepts to human dialysis. Even under the dark cloud of world war, Kolff and his associates managed to construct a dialyzer in 1943. However, progress was slow. The crude dialyzer failed to save the first 16 patients placed on it, and these patients suffered acute renal failure. In 1945, a woman in a uremic coma survived and lived seven more years and the future looked bright.

However, when Dr. Kolff moved to the United States following the war, he was not recognized or supported for his efforts. He struggled again for success. At Peter Bent Brigham Hospital in Boston, Kolff met George Thorn, who modified the dialyzer with a stainless steel container and later called it the Kolff-Brigham kidney. This new machine saved many American soldiers during the Korean War and paved the way for the first kidney transplant in 1954. Because machines were not thought to work as well over time as natural organs and puncture sites would be difficult to find after continual trauma, the dialyzer was not promoted.

Dr. Belding Scribner, from the University of Washington, formed a connection between an artery and a vein using plastic tubing and a shunt device with a new material called Teflon. By the 1960s, small portable units were made and hemodialysis could be performed at home. Dr. Kolff, however, is considered the father of dialysis, and he was instrumental in developing the heart-lung machine and the artificial heart. In the past 60 years, incredible advancements have been made in kidney treatments. Today, at age 93, Dr. Kolff is still inventing. Pioneers of the past like Drs. Kolff and Scribner continue to provide futures for so many in the present.
Functions of the Kidney

The kidneys filter the blood, producing approximately 1 milliliter of urine per minute. In fact, between 20% and 25% of the body’s blood volume is contained within the kidneys at any given time. As they filter the blood (plasma), the kidneys maintain water and electrolyte balance, and they maintain pH levels. The kidneys also produce hormones like erythropoietin, which stimulates red blood cell production, and renin, which elevates blood pressure.

The Nephron

The functional unit of the kidney is the nephron. Approximately 1 million nephrons reside in each kidney. As blood passes through the nephrons, metabolic waste products are filtered from the blood plasma. At the same time, most of the water (99%) is reabsorbed along with nutrients such as glucose and amino acids. Extra water, unwanted ions, some drugs, and metabolic wastes are then excreted. The product at the end of the nephron is urine.

Each nephron consists of a pair of arterioles, a glomerulus, a glomerular capsule, a proximal convoluted tubule, a loop of Henle, and a distal convoluted tubule that leads to a collecting duct. The components of the nephron unit are shown in Figure 10–1.

Formation of Urine

Blood in the renal arteries enters a tuft of capillaries called the glomerulus, which is situated inside the glomerular capsule. These capillary walls are very thin and porous, and the blood pressure within them is higher than the pressure in the surrounding capsule. When blood enters these capillaries, fluid filters into the glomerular capsule. This blood filtrate is equivalent to protein-free plasma. In a healthy nephron, neither protein nor red blood cells pass through the filter into the glomerular capsule.

In the proximal convoluted tubule, most of the nutrients and a large amount of water are reabsorbed and taken back into blood capillaries surrounding the tubules. Salts, particularly sodium and chloride, are selectively reabsorbed according to the body’s needs. Eventually, about 99% of the water is also reabsorbed along with the salts.

The nitrogen-containing waste products of protein metabolism, urea and creatinine, pass on through the tubules to be excreted in the urine. Those substances that are in excess in the body fluids, such as hydrogen ions when the fluid is too acidic, are secreted into the distal tubules to be excreted.

Aldosterone and antidiuretic hormone (ADH) play very important roles in the regulation of salt and water reabsorption. These hormones are discussed in detail in Chapter 12.

Urine from all the collecting ducts eventually empties into the renal pelvis, the juncture between the kidneys and the ureters, and moves down the ureters to be stored in the urinary bladder. Following the signals given by the micturition process, the bladder empties urine into the urethra, which leads outside the body. Figure 10–2 illustrates the urinary system.

Diagnostic Tests and Procedures

Pain, dysuria (painful urination), blood or pus in urine, or edema indicates kidney disease, but specific diagnostic tests are required to determine the nature of the disease. Edema is caused by the loss of protein from the blood; these blood proteins have a water-holding power within the blood vessels. With their depletion, fluid moves out of the capillaries and into the tissues, causing swelling or puffiness.

Significant information can be obtained by a simple diagnostic procedure, a urinalysis, in which a urine specimen is studied physically, chemically, and microscopically. Physical observation allows notation of urine color, pH, and specific gravity of a urine specimen. A centrifuged urine sample is examined microscopically for solids such as crystals, epithelial cells, or blood cells.

Chemical tests (e.g., Chemstrip) reveal the presence of abnormal substances such as protein (specifically albumin), glucose, and blood. Urine is normally yellow or amber, but hema-
Figure 10–1  The kidney with an expanded view of the nephron.
turia (blood in the urine) can darken the color to a reddish brown. The degree of color depends on the amount of water the urine contains. Urine is pale in the case of diabetics, whose water output is large. In long-standing kidney diseases, the ability of the tubules to concentrate the urine is lost. As a result, the urine is dilute and pale, and the specific gravity is low, as found in chronic glomerulonephritis.

The pH of urine has a broad range. The ability of the kidneys to excrete acidic or alkaline urine typically permits the kidney to regulate the pH of the blood within narrow limits. Urine specimens should be examined when fresh because they tend to become alkaline on standing due to bacterial contamination. Urine from a cystitis patient tends to be alkaline for the same reason.

Albuminuria indicates inflammation of the urinary tract, particularly of the glomeruli. The inflammation increases the permeability of blood vessels, allowing protein and albumin to enter the nephrons and appear in the urine. This continual protein loss reduces the level of water “holding power” by the blood (plasma) and results in hypoproteinemia, leading to a loss of fluids to the surrounding tissues and causing edema. Clinitek 50 or Clinitek 100 microalbumin reagent strips are used on an overnight sample when determining hypoalbuminemia.

The presence of sugar (glucose) in the urine usually indicates diabetes mellitus. This is not a sign of a disease of the kidneys, but of the pancreas. Diabetes over an extended period of time adversely affects the kidneys (see Chapter 12). Diabetes insipidus is another endocrine problem due to the lack of ADH or reduced sensitivity of the kidney tubules to the hormone. In either case, the kidney loses its power to control water maintenance and the patient dehydrates due to copious water loss. Treatment involves ADH-type medication such as Pitressin (vasopressin) or Daipid (lypressin) that helps resolve the occurrence of dehydration.
Hematuria may be obvious to the naked eye or require microscopic determination. Hematuria is associated with many serious diseases of the urinary tract, including glomerulonephritis, kidney stones, tuberculosis, cystitis, and tumors. If the passage of urine is accompanied by pain, then a stone, an infection, or potentially tuberculosis would likely be the cause. Painless hematuria indicates the possibility of a malignant tumor in the urinary system.

Pyuria results from a suppurative inflammation caused by pyogenic bacteria that causes the urine to appear cloudy. Microscopic examination of the urine reveals numerous leukocytes. Diseases such as pyelonephritis, pyelitis, tuberculosis, and cystitis show pus in the urine.

Casts are shaped like cylindrical rods because they form within kidney tubules. These cast structures consist of coagulated protein, a substance not normally present in kidney tubules. Casts can include various kinds of blood cells as well as epithelial cells from the lining of the urinary tract, and they always indicate inflammation.

Microscopic examination determines the presence or absence of bacteria. Bacteria are found in tuberculosis of the kidney, pyelonephritis, and frequently in cystitis. For microscopic examinations, a urine sample may be removed from the bladder by catheterization to ensure that no external contamination occurs.

A cystoscopic examination enables the healthcare provider to view the inside of the bladder and urethra. The cystoscope is a long, lighted instrument resembling a narrow hollow tube. Tumors, stones, and inflammations may be identified with this device. Using an additional instrument, small tumors or polyps may be removed or biopsied. Stones in the bladder can be crushed or surgically removed.

The intravenous pyelogram (IVP) allows the visualization of the urinary system by means of contrast dyes injected into the veins followed by x-ray examination. When these dyes concentrate in the urinary system, it is possible to note tumors, obstructions, and other deformities. A kidney is viewed by renal ultrasound, and the whole urinary system is surveyed by computed tomography (CT) or kidney, ureter, bladder (KUB) exams.

**Diseases of the Kidney**

**Glomerulonephritis**

Glomerulonephritis is an inflammatory disease of the glomeruli. It is nonsuppurative; that is, no pus formation, and therefore no bacteria are found in the urine when examined microscopically during a urinalysis procedure. Glomerulonephritis is typically caused by an antigen-antibody reaction that occurs approximately 1 to 4 weeks following a skin (e.g., impetigo) or throat infection by a hemolytic streptococcus bacterium. Antigens from the streptococci and the defensive antibodies form complexes in the bloodstream that become trapped within the glomeruli, causing an inflammatory response. Numerous neutrophils crowd into the inflamed glomeruli, and blood flow to the nephrons is reduced. The impeded blood flow causes a reduction in the filtration rate and results in decreased urine formation. Many glomeruli degenerate, and the remaining glomeruli become extremely permeable, allowing albumin (plasma protein) and red blood cells to appear in the urine (Figure 10–3). Primary signs of glomerulonephritis include proteinuria, hematuria, edema, and hypertension.

Additional causes include other infective agents (e.g., viruses), parasites (malaria), vasculitis (inflamed blood vessels or lymph vessels), systemic lupus erythematosus (SLE), and Goodpasture syndrome, described later in this chapter.

Acute glomerulonephritis is most common in young children, but it can occur at any age and usually follows a streptococcal infection from a prior sore throat or skin inflammation (e.g., erysipelas). The symptoms include chills and fever, loss of appetite, and a general feeling of weakness. There may be edema, or puffiness, particularly in the face and ankles. A urinalysis shows albuminuria, the presence of the plasma protein albumin in the urine. Hematuria, blood in the urine, is also commonly found. Casts, which are the structural elements or molds of kidney tubules consisting of coagulated protein and blood, are present. The signs and symptoms of acute glomerulonephritis are presented in Figure 10–4.
The prognosis for acute glomerulonephritis is good. Normal kidney function is generally restored following bed rest and dietary restrictions (e.g., reduced intake of salt). Medications used for treatment include diuretics, calcium channel blockers, and beta blockers.

Repeated attacks of acute glomerulonephritis can lead to weakened kidneys and a chronic condition.

**Chronic Glomerulonephritis**

Chronic glomerulonephritis may persist for many years with periods of remission and relapse. Hypertension generally accompanies this disease. As more glomeruli are destroyed, blood filtration becomes increasingly impaired. Prevalence of glomerulonephritis is inconclusive, but the chronic cases are estimated at less than 1%.

Part of a urinalysis examination is a simple procedure using a urinometer to determine the extent of kidney function; this is known as a specific gravity (sp. gr.) measurement of a urine specimen. The sp. gr. measurement indicates the amount of dissolved substances or solid elements within a urine sample compared to distilled water. Distilled water has a specific gravity of 1.000, and the normal specific gravity of urine is about 1.015 to 1.025 within a broader overall range of 1.003–1.030. In advanced chronic glomerulonephritis, the specific gravity is low
and fixed, indicating that the kidney tubules are unable to concentrate the urine. (See Appendix C for normal urine values.)

Urinalysis procedures basically require the visual observation of a urine sample, chemical tests (e.g., Chemstrip/Multistix) and microscopic evaluation.

Chronic glomerulonephritis causes the kidneys to shrink, as they gradually atrophy, and cease to function. Uremia, a buildup of metabolic toxins in the blood, results from kidney failure. Chief among these waste products is urea, a small, water-soluble nitrogenous molecule that easily penetrates red blood cells and causes their destruction (hemolysis). Therefore, uremia is often associated with gastrointestinal, neuromuscular, and cardiovascular insufficiencies.

Individuals suffering uremic toxicity experience nausea, headache, dizziness, and faint vision. Left unchecked, this condition may result in convulsions and coma. Dialysis treatment is quickly recommended to restore blood nitrogen and electrolyte balance, in order to reduce symptoms.

**Goodpasture Syndrome**

Goodpasture syndrome (GPS) is a rarely occurring renal problem considered to be an autoimmune disease. The precise cause of Goodpasture syndrome is not known, although it may be triggered by viral agents attacking the respiratory system or by inhaling hydrocarbon solvents. Therefore, the lungs and kidneys may be stressed together or individually. It develops in days to weeks, and once the body attacks the agents mentioned above, or unknown causes, it tends to attack itself. The primary "glue" that the body uses for constructive support, a protein known as collagen, is somehow recognized as foreign and becomes the target of immune responses, somewhat similar to glomerulonephritis cases. Unfortunately, these autoantibodies are directed against the basement membranes of the glomerular capillaries; this disorder is also called antilglomerular basement membrane glomerulonephritis. In this case, the inflammatory disease results in scarring and fibrosis of the glomerular structure (see Figure 10–4). These same autoantibodies (anti-GBM antibodies) are found in Goodpasture syndrome and must be removed in order to improve the functional unit.

Symptoms of GPS vary and include foamy urine, weakness, nausea, and vomiting. Signs include hematuria, oliguria (low urine production), and proteinuria. In addition, respiratory symptoms include hemoptysis, coughing, dyspnea, and chest pain. Diagnostics require physical exam, urinalysis, and more refined chemical tests.

Treatment requires cleansing the plasma of antibodies, and this is accomplished by plasmaphoresis. This process gleans out the causative agents and replaces lost plasma with donor plasma and/or fluids and protein. Dialysis may be required in progressive cases or when permanent kidney damage is moderate; in advanced cases, a kidney transplant is recommended.

Preventative steps are to avoid solvent-type fumes, many of which are aromatic (sweet smelling) and dangerous (e.g., glue sniffing). Use protective gear wherever industrial or commercial fumes are involved.

**Systemic Lupus Erythematosus or Lupus Nephritis**

Lupus nephritis results when autoantibodies collect in the glomeruli which causes a major inflammation sufficient to create scars and reduce kidney functioning. Primary treatment involves two drugs in tandem; one to reduce inflammation, prednisolone, and one to suppress the immune system, cyclophosphamide or mycophenolate mofetil. Kidney function is vital, especially when the whole body is attacked by another (autoimmune) disease.

**IgA Nephropathy**

In this disease, the immunoglobulin A (IgA) forms deposits in the glomeruli causing inflammation. The most common symptom is blood in the urine (hematuria), but it tends to go unnoticed and remain undetected for years. Even without exact numbers, IgA nephropathy is
thought to be the most common cause of primary glomerulonephritis. This status, primary glomerulonephritis, excludes other causes like lupus or diabetes mellitus, which are systemic.

IgA nephropathy is more common in men and young people although it affects all age groups. Because it takes years to become recognized and cause complications, younger people seldom display symptoms. No treatment is recommended for mild cases with normal blood pressure and proteinuria levels, but elevated blood pressure requires medications like ACE inhibitors that seem to work quite well.

**Renal Failure**

Ischemia (reduced blood flow), hemorrhage, poisons, and severe kidney disease may cause renal failure. In renal failure, the kidneys are unable to clear the blood of urea and creatinine, which are nitrogen-containing waste products of protein metabolism. These metabolic products are toxic if they accumulate in the blood. Uremia signifies the terminal stage of renal insufficiency.

The level of blood urea nitrogen, or BUN, reflects the degree of renal failure. Measurement of the glomerular filtration rate (GFR) also can assess the severity of renal disease or follow its progress. GFR is evaluated through tests designed to determine the ability of the kidney to clear the waste product creatinine. Serum creatinine level rises and creatinine clearance rate falls when the GFR is impaired. As may be expected, creatinine clearance levels decline in renal insufficiency and with aging. The test for creatinine is the most specific for kidney functioning and therefore a crucial diagnostic measurement.

**Acute Renal Failure** Acute renal failure may develop suddenly but has a better prognosis than chronic renal failure. Acute renal failure is caused by various factors such as decreased blood flow to the kidneys resulting from surgical shock, including shock following an incompatible blood transfusion, or severe dehydration. Kidney disease, trauma, or poisons from toxic fumes or heavy metals can also cause acute renal failure.

Significant signs of acute renal failure are characterized by a sudden drop in urine volume, called oliguria, or complete cessation of urine production, called anuria. Symptoms include headache, gastrointestinal distress, and the odor of ammonia on the breath caused by accumulation in the blood of nitrogen-containing compounds. Of special concern is hyperkalemia. This elevated blood potassium causes muscle weakness and can slow the heart to the point of cardiac arrest. Treatment includes restoration of the blood volume to normal, with necessary electrolytes, restricted dietary fluid intake, and dialysis as needed.

**Chronic Renal Failure** Chronic renal failure is life threatening and has a much poorer prognosis than acute renal failure. Chronic renal failure results from long-standing kidney disease such as chronic glomerulonephritis, hypertension, and diabetic nephropathy (DN), a kidney disease resulting from diabetes mellitus.

Diabetic nephropathy, as in glomerulonephritis, is due to thickening of the glomerular apparatus that permits relatively high levels of protein (albumin) to escape into the urine. This glomerular change may be very slow, and routine urinalysis methods may not detect a small continual protein loss. Called microalbuminia, it requires a more comprehensive or sensitive test within the urinalysis procedure to detect protein. Unless other factors (e.g., hypertension, family history) indicate the need for a more reliable test, the albumin continually goes undetected. Early-stage diabetic nephropathy has no symptoms, but as the condition advances it becomes more noticeable and debilitating.

Diabetics are particularly at risk if blood glucose remains uncontrolled and high blood pressure is pronounced. A host of symptoms becomes apparent as diabetes nephropathy evolves over a 5- to 10-year span. These symptoms include fatigue, headache, generalized itching, frothy urine, frequent hiccups, and edema, particularly in the legs. A kidney biopsy is the confirming element of a diagnosis, and it helps determine the extent of the disease. However, if the protein loss is progressive or diabetic retinopathy is noted, the biopsy may be too risky.

Today DN is recognized as the most common cause of chronic kidney failure and end-stage renal disease (ESRD) in the United States.
Chronic renal failure responds to diuretic intervention until alternative measures are warranted, such as kidney dialysis or transplant. Drugs such as furosemide (Lasix) and torsemide (Demadex) will help reduce edema and hypertension as well, because hypertension is a medical priority. Either separately or in combination, angiotensin converting enzyme (ACE) inhibitors or angiotensin receptor blockers (ARBs) would be utilized. Additionally, controlling weight, blood lipids, and sugar levels and engaging in regular exercise are recommended. Common over-the-counter drugs like ibuprofen or aspirin tend to aggravate or weaken the kidney and are discouraged. As the condition worsens and ESRD develops, in which kidney function declines to less than 10% of normal, the option of choice is kidney transplant or kidney-pancreas transplant when available. Even with a successful transplant, continued diligence is necessary, such as dietary considerations for restricting salt and fluid intake and monitoring for anemia or infection.

The condition develops slowly, with urinary output dropping slowly over time. Metabolic wastes accumulate in the blood, with adverse effects on all body systems. For example, urea builds up to toxic levels, and some is converted to ammonia, which acts as an irritant in the gastrointestinal tract, producing nausea, vomiting, and diarrhea. Vision becomes dim, cognitive functions decrease, and convulsions or coma may ensue. Manifestations of chronic renal failure are summarized in Figure 10–5. These cases are now primarily considered end-stage kidney disease.

Renal failure is treated with kidney dialysis, a technique that removes toxic substances from the blood. Known as hemodialysis, blood is removed from the body, toxic substances are removed from the blood, and the blood is returned to the body (Figure 10–6). For hemodialysis, a patient typically must visit a clinic or hospital for dialysis and stay for 3 to 6 hours during the process. However, residential dialysis units are available that allow patients more convenient and private treatment. Small portable dialysis units have further reduced cost and have increased availability for treatment.

In peritoneal dialysis (PD), dialyzing fluid is introduced into the abdominal cavity, where the peritoneum (cavity lining) acts as a filter membrane. The fluid draws toxic materials out of capillaries surrounding the body cavity, and after a suitable amount of time, the peritoneal fluid is removed, along with its dissolved toxins. A bag may be attached externally to collect the fluid, permitting the patient to remain mobile and providing more freedom and flexibility during treatment. Dialysis may be required for years but may not be sufficient in advanced chronic renal failure.

Another alternative treatment for advanced kidney failure is kidney transplant. Advances in antirejection medications have reduced complications and allowed kidney transplants to prolong and save thousands of lives (Figure 10–7). Prevention of ESRD requires early detection to halt chronic kidney failure, even though it may take many years (10–20) to develop. With advanced age, other ailments, or lack of attention, ESRD may not be preventable. Currently more than 400,000 Americans are on long-term dialysis and more than 20,000 have functioning kidney transplants.

**Pyelonephritis**

*Pyelonephritis* is a suppurative urinary tract infection of the kidney and renal pelvis caused by pyogenic (pus-forming) bacteria, including *Escherichia coli*, *streptococci*, and *staphylococci*. **Figure 10–5** Manifestations of chronic renal failure.
Obstruction of the urinary tract, such as a congenital defect, a kidney stone, or an enlarged prostate gland, slows urine flow and increases the risk for infection. The infection may originate in the bladder and ascend up into the kidneys, or it may originate in blood or lymph and descend to the kidneys as is found in tuberculosis. Figure 10–8 shows the possible routes of infection.

In pyelonephritis, abscesses form and rupture, draining pus into the renal pelvis and the urine. Pus in the urine is called pyuria, which causes a turbid or cloudy appearance in the urine sample, and may be detected during a urinalysis procedure. The abscesses can fuse, filling the entire kidney with pus. Left untreated, pyelonephritis may lead to renal failure and uremia. In less severe infections, healing occurs but scar tissue tends to form. Because fibrous scar tissue tends to contract, the kidney shrinks and becomes what is described as a granular contracted kidney.

Symptoms of pyelonephritis include chills, high fever, sudden back pain that spreads over the abdomen, dysuria, and hematuria. Microscopic examination of the urine reveals numerous pus cells and bacteria. Treatment includes antibiotics, such as aminoglycosides (Amikin) or sulfonamides (Bactrim, Septra), for the infection.

**Pyelitis**

Pyelitis is an inflammation confined to the renal pelvis, the juncture between the ureter and the kidney. Pyelitis is caused by *E. coli* and other pyogenic bacteria. The bacteria may originate from a urinary bladder infection or the blood. Pyelitis occurs commonly in young children, particularly girls, because the urethra in females is much shorter than that of males. Microorganisms from fecal contamination can enter
Figure 10–8  Routes of infection for pyelonephritis.

from the outside and easily travel to the bladder. The infection can then spread up the ureter to the renal pelvis. Dysuria as well as increased frequency and urgency are common symptoms of pyelitis. A urinalysis exam will reveal numerous pus cells.

This disease responds well to treatment with antibiotics, as previously mentioned. Early diagnosis and treatment are important in preventing the spread of the infection into the kidney tissue, which leads to pyelonephritis.

Renal Carcinoma

Kidney cancer, also called hypernephroma, causes enlargement of the kidney and destroys the organ. Renal carcinoma is a relatively rare type of kidney cancer, comprising only 3% of all adult cancers, but causes 85% of all kidney cancers. Two other types, transitional cell carcinoma and sarcoma, make up the remaining 15% of kidney cancers. The incidence of kidney cancer in men is twice that for women, and it normally occurs between ages 50 and 60. Smokers are twice as likely as nonsmokers to develop kidney cancer.

The tumor may not manifest itself for several years. Painless hematuria eventually becomes the chief sign. When the tumor becomes large, an abdominal mass may be felt. This mass can then be detected on an x-ray as a tumor of the kidney. Metastasis to other organs often occurs before the presence of the kidney tumor is known. The malignancy frequently spreads to the lungs, liver, bones, and brain. Besides pain, typical signs include loss of appetite, weight loss, anemia, and an elevated white blood cell count (leucocytosis). Surgical removal (nephrectomy) is the best initial treatment.

A malignant tumor of the kidney pelvis that develops in children, usually diagnosed between ages 2 and 5, is Wilms’ tumor, an adenosarcoma. A fast-growing tumor, it metastasizes through the blood and lymph vessels. Symptoms and signs include hematuria, pain, vomiting, and hypertension similar to symptoms of renal carcinoma in an adult. Diagnosis is done by an IVP and confirmed by kidney biopsy. In recent years, without metastasis, surgery and radiation (except stage 1) and chemotherapy treatment that may be intermittent, lasting 6 to 15 months, offer a good prognosis.

Wilms’ tumor, found in 1 in 10,000 individuals, has a genetic connection. It appears that at least three different genes influence the occurrence of this disease. The Wilms’ tumor gene 1 (WT-1), whose actual function is unknown, seems to play an important role in embryonic development. When this particular gene is missing or mutated, congenital defects appear, and this abnormal tissue later becomes the site of cancer.

Kidney Stones

Kidney stones, known as urinary calculi, predominantly form in the kidney. The prevalence of urinary calculi is approximately 10%, and by age 70, 5% to 15% of all U.S. citizens experience kidney stones. Men are four times more likely than women to produce renal calculi, with the first episodes occurring between ages 20 and 40.
Urinary calculi may be present and cause no symptoms, even when passed through the urinary tract, unless they are larger than a quarter-inch in diameter, in which case they become lodged in the ureter. The lodged stones cause intense pain that radiates from the kidney to the groin area. In addition to intense pain, other signs and symptoms include hematuria, nausea, vomiting, and diarrhea.

Kidney stones may cause urinary tract infections by blocking urine flow and permitting bacterial growth in the urinary tract. Conversely, a urinary tract infection that blocks urine flow can trigger kidney stone formation because of urine stasis in the renal pelvis. Calculi are formed when certain minerals in the urine form a precipitate; that is, come out of solution and grow in size. Bacteria in urine can serve as sites for calcium deposition. The resulting stones, if small enough, can be passed in the urine, but larger stones may require surgery or other treatment.

Four renal calculi formations are recognized. Calcium stones comprise 80% of all kidney stones and consist mainly of calcium salts, calcium oxalate, and calcium phosphate. Calcium excess often leads to stone formation. Hyperactive parathyroid glands can cause the excess of circulating calcium, promoting formation of urinary calculi. Therefore, the parathyroids may need to be controlled or surgically removed, especially with rapid recurrence of stones. No evidence suggests that “hard water” influences kidney stone formation. Men are four to five times more likely than women to form these stones. Uric acid stones comprise 10% of all stone formations and occur especially in men subject to gout. Colon surgery increases the risk for uric acid stones. When portions of the colon are removed, the urine becomes more acidic, which enhances the formation of uric acid stones. Struvite stones, also called infection stones, comprise nearly 10% of stone formations. Bacterial growth in these kidney stones produces ammonia, making the urine alkaline, which also triggers stone precipitation. When bacteria become encased in minerals, antibiotics are ineffective, and the stones tend to enlarge. A stone may become so large that it fills the renal pelvis completely, blocking the flow of urine, and requires surgical removal. A stone of this type, named for its shape, is the staghorn calculus illustrated in Figure 10–9. A kidney containing numerous small calculi is also shown. Cysteine stones account for the remaining 1% of the renal calculi. These stones are aggregates of the amino acid cysteine, which does not dissolve easily in water. Cysteine stones result from a hereditary disorder in which the kidneys fail to reabsorb cysteine, which builds up in urine, precipitates, and eventually forms stones, more commonly in children.

Stones can also form in the urinary bladder. The presence of bladder stones causes urinary
tract infections because they frequently obstruct the flow of urine.

Diagnostic tools include CT, IVP, renal ultrasound/scan, and a KUB exam that consists of a single x-ray without dye to view the abdominopelvic region.

Urinary calculi may be treated with medication that partially dissolves the stone, permitting it to be passed in the urine. **Lithotripsy**, the crushing of kidney stones, is effective for the 20% of kidney stones that do not pass on their own. In lithotripsy, sonic vibrations are applied externally, and focused internally, to crush the stones. If performed while the patient is immersed in a tank of water, the procedure is called **hydrolithotripsy** (Figure 10–10). In this technique, the patient while partially submerged is subjected to the sonic waves that shatter the hard stones into sand-sized particles that can be eliminated within the urine.

**Prevention PLUS!**

**Kidney Stones**

To prevent kidney stones or their recurrence, it is recommended that urine output be increased. Drinking greater quantities of fluids, especially water, dilutes the urine and solubilizes the potential stones. Cranberries have been used for over 150 years to prevent urinary infection. Drinking the juice increases urine acidity, which reduces microbe growth and inhibits bacteria from adhering to the urinary bladder wall. Especially the unsweetened juice and even the capsule form seem to help prevent kidney stones.

---

**Figure 10–10** Extracorporeal shock-wave lithotripsy. Acoustic shock waves generated by the shock-wave generator travel through soft tissue to shatter the renal stone into fragments, which are then eliminated in the urine. (A) A shock-wave generator that does not require water immersion. (B) An illustration of water immersion lithotripsy procedure.
stream. Recovery is rapid, but there may be some bruising, and the patient usually requires a maximum one-day hospital stay.

Recurrence of stones is not uncommon; after the first stone passes, 14% recur within the first year, about 35% recur within 5 years, and up to 52% recur within 10 years. To avoid or reduce recurrence, fluid intake should be increased to keep the urine dilute, and dietary calcium and protein should be reduced. Certain fruit juices (e.g., cranberry) are purported to benefit patients with calcium-forming stones.

**Hydronephrosis**

As a result of urinary calculi, a congenital defect, a tumor, an enlarged prostate gland, or other obstruction of the renal pelvis, the kidney may become extremely dilated with pockets of urine (fluid). This condition is called **hydronephrosis**. The ureters dilate above the obstruction from the pressure of urine that is unable to pass and are referred to as **hydroureters**. Figure 10–11 shows this dilated condition. A physical cause for hydronephrosis is a **ureterocele**. In this case, the terminal portion of the ureter **prolapses**, or slides into the urinary bladder. When detected, it can be corrected surgically.

Hematuria is generally present, and the degree of pain accompanying hydronephrosis depends on the nature of the blockage. If an infection develops because of the stagnation of urine, pyuria and fever occur (Figure 10–12).
Polycystic Kidney

Solitary renal cysts are relatively common, with sizes varying from a few millimeters to 15 mm (the latter may have little effect on kidney function). However, the polycystic kidney is a congenital defect, an error in development that usually involves both kidneys. An autosomal recessive gene causes polycystic kidney in children, while in adults it is caused by an autosomal dominant gene. Adult polycystic kidney disease affects 1 of every 500 to 1000 individuals.

The cysts are dilated kidney tubules that do not open into the renal pelvis as they should. Instead, the cysts enlarge, fuse, and usually become infected. As the cysts enlarge, they compress the surrounding kidney tissue. The accompanying Side by Side illustrates the polycystic kidney of an adult. By middle age, signs and symptoms appear, including pain, hematuria, polyuria, renal calculi, and hypertension. This disease may be diagnosed with a combination of a physical exam, a renal ultrasound or CT, or an IVP (see “Diagnostic Tests and Procedures”).

No specific treatment is available. Renal failure eventually occurs, requiring dialysis or kidney transplant.

Cystitis

Cystitis is an inflammation of the urinary bladder primarily caused by an infection. It is more common in women than in men because of women’s shorter urethra. The chief cause is E. coli, which resides in the colon and can reach the urethra and ascend upward into the bladder. Cystitis can also develop following sexual intercourse if bacteria around the vaginal opening spread to the urinary opening. Occasionally, pressure from coughing or exertion squeezes the bladder, which pushes some urine into the urethra and then draws it back to the bladder. This action contaminates the normally sterile fluid within the urinary bladder.

The symptoms of cystitis are increased urinary frequency and urgency and a burning sensation during urination. Microscopic examination of the urine reveals bacteria, pus, casts, and leukocytes. Treatment depends on the type of bacteria and may include a type of penicillin, such as ampicillin or amoxicillin.
Urinary Incontinence (UI)

Very early in life, urinary incontinence is considered the norm, as it often is in the elderly years. Although adult incontinence is not a disease, it is abnormal and does require attention. Numbers range from 20 to 30 million sufferers in the United States. This involuntary (or unwanted) release of urine from the urinary bladder is an inconvenience and often an embarrassing problem for those individuals afflicted. Adults may alter their social and physical habits due to this problem.

For the infant, the inability to control micturition occurs because the nerves and muscles have not been coordinated to allow closure of the (voluntary) external urethral valve or sphincter. Automatic reflexive voiding of the urinary bladder occurs because the walls of the bladder expand, and the stretch receptors within the walls signal the internal valve to relax. Otherwise, until the bladder responds to the stretching, the collected urine is retained. A similar mechanism occurs in adults, but conscious efforts allow the voiding signals to be damped down and the external sphincter to remain closed. Urinary retention occurs when the bladder is unable to fully expel the contained urine in a timely fashion due to weak abdominal muscles or extraneous factors such as anesthesia (muscles need time to recover). Within the central nervous system, the pons, cerebral cortex, and spinal cord coordinate to inhibit micturition, or to allow it to occur. Once the timing is convenient and appropriate, urination proceeds.

A myriad of causes and treatments are found for UI. Obviously, UI is subject to various diseases, like infection or stroke, and heredity. Conditions such as childbirth, pregnancy, hysterectomy, and menopause may also be involved. A tumor or enlarged prostate that compresses the urethra, or a prostate surgery, may leave the male incontinent. UI may be inadvertently induced by medications that are used to control hypertension, antihistamines, muscle relaxants, and sleeping pills.

Whatever the primary cause, there are three basic forms of adult UI: (1) overflow incontinence, in which the bladder overfills and tends to dribble urine out the urethra; (2) stress incontinence, in which the urethral sphincter is weak or damaged and allows leakage upon coughing, sneezing, laughing, or increased abdominal pressure; and (3) urge incontinence, in which the muscular bladder wall has sudden uncontrolled contractions.

Depending on cause, severity, age, and other factors, UI is managed by methods ranging from the very simple to surgical. Wearing sanitary napkins, incontinence pads, or waterproof briefs may suffice initially or be preferred. Additional attention to voiding the bladder more often and extending the timing may help along with exercising the pelvic muscles and the urethral valves. These pelvic maneuvers are known as Kegel exercises and when performed several times each day may be sufficient to control some stress-type incontinence.

Collagen injections near the voluntary external sphincter may reduce the urethra passage sufficiently to prevent accidental urine release. Somewhat more invasive surgeries suspend the bladder to a greater degree to allow the bladder neck and urethra to form a better alignment and improve normal functioning. Overflow incontinence may be treated by voiding the bladder more frequently, on demand if possible, or if needed by medications like oxybutynin or tolterodine.

When the condition becomes chronic or causes pain or infection, a tubular catheter may be inserted up into the bladder via the urethra to insure voiding the bladder contents. Catheters are small-diameter flexible tubes made of “plastic” (polyvinyl chloride; PVC) or latex primarily inserted through the urethra into the bladder and range from 4 to 12 inches long per gender. A balloon device is at the inserted end and expanded once in place to prevent escape. Externally a retention bag is attached to the catheter and has a capacity of 0.5 L to 2 L depending on daily and overnight usage. It is important to empty the bag frequently (e.g., every 4 hours) and keep a fresh or cleansed container in place. For more mobility, the external retention bag may be strapped to the thigh, pelvic area, or calf position.
The catheter arrangement may be short term (a few days to 2 weeks) or long term (at least 2 years) depending on the circumstance. Long-term setups require a surgical procedure to tap directly into the bladder from the outside through the pelvic wall just superior to the symphysis pubis. Known as an indwelling catheter, these tubes are constructed of latex and may be coated with Teflon or silicone plus antibiotics if necessary.

Irritation by any tube in the bladder presents the potential for bladder infection (or beyond) and bladder stones. Therefore, an external catheter may be used such as a condom or penile sheath for men or a labial funnel-type device to adhere to the female external genitalia (or vulva). Either device is then attached to a tube that drains into a retention bag. Over time the type of catheter arrangement may change depending on situation or preference.

Incontinence that continues into the early juvenile years is called enuresis, or bedwetting. About 1 in 9 children has this UI, which is more common in boys by a margin of 2 to 3. Usually, it is outgrown within the first 11 years (72%) or by age 15 (99%).

Causes for enuresis, or nocturia, include lack of bladder growth or development, heredity (40%–70% of cases), heavy sleep, and a reduced level of ADH at night. Besides diapers or absorbent pads to prevent bedtime pools, the youngster may use a nasal spray (e.g., desmopressin acetate) that acts like ADH to prevent bedwetting. Some cases are better served through counseling, urination regiment, or bladder conditioning to reduce night-time urinating accidents.

**Neurogenic Bladder**

A neurogenic bladder tends to result in urinary incontinence due to lack of nervous system control. Damage to the nerves supplying the bladder or a breakdown within the central nervous system (CNS) is the root cause of this problem. A common cause is a spinal cord injury from vehicular accident or other trauma. Physical dilemmas like herniated disks in the lumbar region or tumors compressing on the spinal cord and/or spinal nerves are highly probable causations. Metabolic disorders, especially diabetes, mental challenges like Alzheimer’s disease, and other CNS dysfunctions like Parkinson’s disease and multiple sclerosis (MS) tend to cause bladder impairment as well.

Symptoms vary with the severity or particular nerve(s) involved and the primary dysfunctional location. The bladder may spasm, fail to empty completely, or lack of the feeling of fullness or urgency, and thus the signal to evacuate may go undetected. Diagnosis is therefore difficult to ascertain. Beginning with an extensive patient history coupled with a full-scale neurological exam and a careful urological evaluation, a probable cause and prognosis may be set forth. The goal is to restore bladder function fully, and that may require a major neurological investigation. Urological treatments include indwelling catheters, hygiene training, and exercise. Lumbar disks may be repaired and drug treatments for CNS dysfunctions may assist the recovery. However, if nerve damage is severe or permanent, a neurogenic bladder will persist.

**Carcinoma of the Bladder**

Certain industrial chemicals and cigarette smoking have been linked to carcinoma of the urinary bladder. Smokers generally have a risk 2 1/2 times higher of contracting bladder cancer than do nonsmokers. Bladder cancer accounts for 3.4% of all new cancers in men and 1.4% of all new cancer cases for women in the United States (2007). The tumor (or polyp) grows by sending fingerlike projections into the lumen of the bladder. Although these tumors can be seen with a cystoscope and removed, they tend to recur. A more invasive pattern of growth involves infiltration of the bladder wall, which cannot be surgically removed without destroying the bladder.

One treatment involves fulguration, an infusion of BCG solution (Bacillus Calmette Guerin), a weakened tuberculosis bacillus that...
coats the bladder’s internal epithelial surface. This solution causes the inner lining to “peel off” and be replaced by new surface cells. This treatment lasts from months to years, depending on the status of the patient. If this procedure is not appropriate or is ineffective, then surgical removal of the cancer is required.

If the entire urinary bladder is surgically removed (radical cystectomy), an ileal conduit (see Figure 10–13) is likely constructed surgically to store and evacuate urine. See Chapter 4 for more information.

**Urethritis**

Any part of the urinary tract can become inflamed, and the urethra is no exception. This tubular inflammation is called **urethritis**. In men, the cause may be a gonococcus or other bacteria, viruses, or noxious chemicals. A trauma caused by a “straddle” accident may cause irritation and damage to the urethra or stressful pressure (e.g., long-distance bicycle riding). Damage to nerves and blood vessels may occur at the same time, and this could cause testicular problems for the male. In women, urethritis frequently accompanies cystitis. An obstruction at the urinary opening may cause the inflammation in women. The symptoms of urethritis include a discharge of pus from the urethra, an itching sensation at the opening of the urethra, and a burning sensation during urination. Treatment includes antibiotics like amoxicillin for bacteria infections.

**Age-Related Diseases**

Several changes accompany the aging urinary system. Basically there is less control over urination (the micturition reflex) because the urethral sphincter muscles lose tone, allowing urine to leak, and due to other factors mentioned earlier. Incontinence tends to be more common with aging, but some suggest that with more conscious effort, training, and some medical advice or attention (e.g., minor surgery) numbers of cases might be reduced or prevented by as much
as 80%. Brain and spinal cord damage may lead to a weak micturition urination reflex.

Dehydration due to water loss via the aging kidneys is possible, because the total number of functioning nephrons declines with age, perhaps as much as 30% to 40% between ages 25 and 85, and the kidney loses sensitivity to ADH. The reduction of renin and therefore aldosterone activity causes a lack of salt and water retention, allowing more urine to be released by the kidney. Urinary retention occurs because bladders lose muscle tone and are unable to empty completely. Obstruction exacerbates urine retention and is common in men because of prostate enlargement. Urinary retention, in turn, increases the risk for urinary tract infections (UTIs). Cancer increases significantly past age 60 for the kidney, and at age 70 for bladder cancer.

**RESOURCES**


Renal Calculi: www.emedicine.com/emerg/topic499.htm
# DISEASES AT A GLANCE

## Urinary System

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>ETIOLOGY</th>
<th>SIGNS AND SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydronephroma</td>
<td>Idiopathic, radiation</td>
<td>Painless hematuria, later pain, loss of appetite, weight loss, anemia, elevated white blood count</td>
</tr>
<tr>
<td>Wilms’ tumor</td>
<td>Idiopathic, genetic (WT-1) chromosome II</td>
<td>In young children, signs and symptoms similar to hydronephroma in adults</td>
</tr>
<tr>
<td>Pyelonephritis</td>
<td>Pyogenic bacteria</td>
<td>Pyuria, chills, high fever, sudden back pain, dysuria, hematuria, eventual renal failure, uremia</td>
</tr>
<tr>
<td>Pyelitis</td>
<td>Pyogenic bacteria</td>
<td>Dysuria, frequency, urgency</td>
</tr>
<tr>
<td>Acute glomerulonephritis</td>
<td>Prior bacterial infection, antigen-antibody complex</td>
<td>Follow strep infection: chills, fever, loss of appetite, weakness, edema, albuminuria, hematuria, casts</td>
</tr>
<tr>
<td>Chronic glomerulonephritis</td>
<td>Hypertension and glomerular destruction</td>
<td>Remission and exacerbation of glomerulonephritis; may end with granular contracted kidneys and uremia; specific gravity low and fixed in advanced cases</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>Incompatible blood transfusion, severe dehydration</td>
<td>Sudden oliguria, may become anuria, headache, GI distress, odor of ammonia in breath, muscle weakness</td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>Hypertension, chronic glomerulonephritis, diabetic nephropathy</td>
<td>Slow development, urinary wastes increase in blood, nausea, vomiting, diarrhea, dim vision, central nervous system affected, convulsions, coma</td>
</tr>
<tr>
<td>Urinary calculi (kidney stones)</td>
<td>Hyperparathyroidism, excess calcium</td>
<td>No symptoms until they block ureter, then intense pain radiating to groin</td>
</tr>
<tr>
<td>DIAGNOSIS</td>
<td>TREATMENT</td>
<td>PREVENTION</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>X-ray</td>
<td>Surgery</td>
<td>Uncertain</td>
</tr>
<tr>
<td>X-ray, sometimes radiation</td>
<td>Surgery, sometimes radiation</td>
<td>None</td>
</tr>
<tr>
<td>Urinalysis, pus and blood in urine</td>
<td>Antibiotics</td>
<td>Depends on exposure and susceptibility</td>
</tr>
<tr>
<td>Urinalysis, numerous pus cells in urine</td>
<td>Antibiotics</td>
<td>Same as above, good hygiene</td>
</tr>
<tr>
<td>Urinalysis, patient history</td>
<td>Antibiotics, steroids, immune suppression</td>
<td>As above or uncertain</td>
</tr>
<tr>
<td>Urinalysis, urine specific gravity low, patient history</td>
<td>Antibiotics, steroids, immune suppression</td>
<td>Prevent negative kidney exposure, or uncertain</td>
</tr>
<tr>
<td>Patient history, blood and urinalysis</td>
<td>Drugs, fluid control, antibiotics, dialysis</td>
<td>Uncertain</td>
</tr>
<tr>
<td>Patient history, urinalysis, blood analysis</td>
<td>Dialysis, kidney transplant</td>
<td>Implies prior kidney stress</td>
</tr>
<tr>
<td>Patient history, blood and urinalysis, x-ray</td>
<td>Lithotripsy, surgery</td>
<td>Consider family history, prevent dehydration, diet</td>
</tr>
</tbody>
</table>
### DISEASES AT A GLANCE

#### Urinary System (continued)

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>ETIOLOGY</th>
<th>SIGNS AND SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydronephrosis</td>
<td>Renal obstruction, congenital defect</td>
<td>Pain, hematuria, pyuria, and fever if infection present</td>
</tr>
<tr>
<td>Polycystic kidney</td>
<td>Genetic</td>
<td>Hypertension, eventual renal failure, uremia</td>
</tr>
<tr>
<td>Carcinoma</td>
<td>Idiopathic, radiation, smoking</td>
<td>Early asymptomatic, hematuria may occur, later pelvic pain and frequent urination</td>
</tr>
<tr>
<td>Urinary Bladder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cystitis</td>
<td>Usually bacteria infection</td>
<td>Urinary frequency, urgency, burning sensation during urination, blood in urine</td>
</tr>
<tr>
<td>Bladder cancer</td>
<td>Idiopathic, smoking, hazardous chemicals</td>
<td>Hematuria, dysuria, fatigue, anorexia</td>
</tr>
<tr>
<td>Urethritis</td>
<td>Microbial agents, viruses, some chemicals</td>
<td>Burning sensation during urination, itching, discharge; in females, accompanies cystitis</td>
</tr>
<tr>
<td>Incontinence</td>
<td>Neurological injury, aging</td>
<td>Involuntary loss of urine</td>
</tr>
<tr>
<td>DIAGNOSIS</td>
<td>TREATMENT</td>
<td>PREVENTION</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>Urinalysis, IVP cystoscopic exam</td>
<td>Relief of obstruction, surgery</td>
<td>Uncertain, depends on (e.g., obstruction due to enlarged prostate)</td>
</tr>
<tr>
<td>Urinalysis, IVP cystoscopic exam</td>
<td>Kidney transplant</td>
<td>None</td>
</tr>
<tr>
<td>Cystoscopy</td>
<td>Surgery</td>
<td>Do not smoke, avoid radiation and other potential carcinogens</td>
</tr>
<tr>
<td>Microscopic exam of urine, may be diagnosed by patient’s description of typical signs and symptoms</td>
<td>Antibiotics</td>
<td>Uncertain, good hygiene</td>
</tr>
<tr>
<td>Cystoscope, IVP, x-ray, CT</td>
<td>Fulguration, radiation, surgery</td>
<td>Uncertain: do not smoke, avoid radiation</td>
</tr>
<tr>
<td>Microscopic exam of urine</td>
<td>Antibiotics</td>
<td>Uncertain, good hygiene</td>
</tr>
<tr>
<td>Patient history</td>
<td>Exercises for muscles of pelvic floor, antibiotics for infection</td>
<td>Varies; requires treatment</td>
</tr>
</tbody>
</table>
3. A mother of a 4-month-old infant, while giving a bath, noticed and palpated a mass on the right side of the child’s abdomen. The child was irritable and somewhat lethargic. What might explain this mass, and what diagnostic techniques can help determine the nature of the disease?

4. A 52-year-old grandfather’s urinalysis revealed blood (hematuria). The x-ray showed a renal mass on the right side. What is the probable cause for the hematuria, and what treatment would be recommended?

6. Which form of kidney dialysis permits a patient to retain mobility?
   a. peritoneal dialysis  b. hemodialysis
   c. hemolysis  d. ileal shunt

7. The inability to control urination is called
   ______________.
   a. micturition  b. incontinence
   c. anuria  d. nocturia

8. What dietary restriction helps to prevent uric acid calculi?
   a. protein  b. dairy products
   c. pasta and citrus  d. spinach, cabbage, and tomatoes

9. What primarily causes the edema associated with nephritic syndrome?
   a. hypertension  b. hyperalbuminuria
   c. decreased plasma protein  d. lower GFR

10. Which of the following includes a reduced sensitivity to ADH, incontinence, and increased urination frequency?
    a. overhydration  b. aging
    c. stress  d. excess nitrogen intake
Chapter Ten  Diseases of the Urinary System  ■  259

True or False

____  1. A sudden drop in urine volume indicates chronic renal failure.
____  2. Cystitis is often an ascending infection.
____  3. In acute uremia, fluid intake should be decreased.
____  4. Albuminuria leads to hypoproteinemia.
____  5. Painful and frequent urination accompanies tuberculosis of the bladder.
____  6. Bacteria are not found in acute glomerulonephritis.
____  7. Pyelonephritis is a suppurative disease.
____  8. The urinary bladder stores urine that may be reused.
____  9. Leukocytes in urine indicate anemia.
____  10. Calcium (oxalate, phosphate) is the most common form of renal calculus.

Fill-Ins

1. ______________ is pus in the urine.
2. ____________________ ____________________ is a kidney disease resulting from diabetes mellitus.
3. Urinary calculi, or ____________________, may be present and cause no symptoms until they become lodged in the ureter.
4. ____________________, the external crushing of kidney stones, is now the preferable procedure to remove kidney stones, replacing the need for surgery.
5. ____________________ ____________________ is a congenital anomaly that usually involves both kidneys.
6. Scanty urine or ____________________ is low urine volume (or formation).
7. Loss of urine at night is called ____________________.
8. Struvite stones are associated with ____________________.
9. Adult polycystic kidney is a genetic disease caused specifically by an autosomal ____________________ gene.
10. An x-ray outline of the urinary system following an injection solution is the diagnostic technique called ____________________.
Labeling Exercise

Use the blank lines below to label the following image.

1. ___________________________
2. ___________________________
3. ___________________________
4. ___________________________
Additional interactive resources and activities for this chapter can be found on the Companion Website. For videos, audio glossary, and review, access the accompanying DVD-ROM in this book.

► DVD-ROM Highlights

**Popping Words**
Popping pills won’t help you study, but popping words might do the trick. Test your knowledge by launching the term pill into the correct definition container. Ready, aim, fire!

**Cognition**
Use your memory to make a match. This variation of the game Concentration will challenge you to study the eight terms and then remember their location to complete a quiz. Click on each tile to reveal the correct answers.

► Website Highlights—www.pearsonhighered.com/zelman

**Fill-in-the-Blanks Exercise**
Take advantage of the free-access online study guide that accompanies your textbook. You’ll find a fill-in-the-blank quiz that provides instant feedback and allows you to check your score to see what you got right or wrong. By clicking on this URL you’ll also access links to current news articles and an audio glossary.